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Volume II Number 9

Superpower

Compiled by
LEMAR T. BEMAN, A.M., LL.B.

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Volume II Number 9

SUPERPOWER

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LAMAR T. BEMAN, A. M., LL. B.

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INTRODUCTION

The superpower (sometimes called giant power) system is the contemplated development and unification in the production and distribution of electric power by the erection of enormous power plants, some to be run by water power, utilizing more fully the water power resources of the country, and some by steam, to be built near coal mines, so as to save the cost of transporting coal, and by the erection of trunk transmission lines. By very large scale production of power, by interconnection, by the recovery of the by-products, by the gradual elimination of the smaller plants, and by the transmission of power for long distances at high voltage, a great saving can be accomplished.

The benefits that are expected to be derived from this system are: 1. Abundant cheaper power, with its possibility of higher wages in the industries which must now pay higher prices for power and its advantage to those of our industries that are now in international competition for the markets of the world. 2. A very great saving in the amount of coal consumed each year. 3. Relief to the transportation system, because it would have less coal to haul. 4. Electrification of at least a part of the railroads. 5. Electric power at low rates will be available in the smaller cities and villages, a fact that some believe will aid in preventing further overcongestion in the great cities, because manufacturing can then be carried on more favorably in the smaller cities where rents and food prices are lower. 6. A reduction in the amount of smoke in the large cities. 7. Electric power will ultimately be brought to the farms.

The superpower system is fast moving from a dream of a few great engineers to a reality, one that many

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believe will effect all human relations as fundamentally as did the industrial revolution. In 1920 the Federal Power Commission was created by the Act of June 20th. In 1921 the United States Geological Survey published Professional Paper No. 123, entitled "A Superpower System for the Region Between Boston and Washington." In 1923 the legislature of Pennsylvania created the Giant Power Survey Board, which is expected to make a report at the next session of the legislature, to be in January, 1925. In 1924 the Federal report on superpower for the northeast was published.

Actual construction has also gone forward. The great power plants at Niagara Falls were pioneers in their time. For several years now travellers have seen their high tension wires extending across southern Ontario and western New York. More recently further advances have been made in the construction of large power plants near coal mines. But the system is still in its infancy. Its development and construction are expected to extend over the next generation.

LAMAR T. BEMAN

September 16, 1924

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REPRINTS

PUBLIC RELATIONSHIP TO POWER DEVELOPMENT[1]

I am privileged to be the instrument by which your association tonight demonstrates that a person may sit at his own desk in Washington and address not only your convention but an audience of five million radio listeners in thirty states through the interconnection of a dozen local broadcasting stations.

This arrangement has both its advantages and its disadvantages. It saves time, and that is an advantage in my kind of a job. But it lacks the personal touch, and that is a disadvantage. To talk to the unresponsive face of a microphone in a lone room has much the same inspiration on the speaker as a certain lecture directed to a doorknob. However, I have a receiving set at my elbow.

Electricity is the greatest tool that has ever come into the hands of man. I propose to say something on the future of its development from a national point of view as I see it. More particularly do I wish to speak of our public relationships to it. The subject is of the highest importance and it is most needful that our people as a whole should understand more of it. I do not propose to invisage a dream of a hundred years hence but to set forth the immediate program necessary to assure continued development. Wisdom consists more in a perception of what to do next than it does in a knowledge of the ultimate.

Some part of this five million audience are unfamiliar

[1] Address by Herbert Hoover, Secretary of Commerce, by radio to the Convention of National Electric Light Association at Atlantic City, May 21, 1924.

with the technology of the electrical industry, although everyone of them knows its use. I shall, therefore, need to avoid the precision of the electrical language in hope of more general understanding. I mention this because I do not wish the members of the association to feel that I am telling you things which you already know, or that I could not talk in terms of kilowatts or volts or high tensions or the hundred other terms of your own tongue if I wanted to.

Present Accomplishment and Future Need

We have outdistanced all the world in our electrical development up to now. Today we have twenty-seven thousand telegraph stations, over fifteen million telephones, over six hundred radio broadcasting stations, over three million receiving sets with possibly fifteen million listeners, nine millions homes are wired for lights, we have the capacity to generate over 27,000,000 electrical horsepower. The American wage-earner has at his elbow 50 per cent more power than any of his competitors. In consequence, his product is greater, his wage higher, and his physical strain is less than any other.

This is itself a fitting tribute to the remarkable ability shown by the men in our whole electrical industry since the days of Mr. Edison's initial genius. Beyond all these evidences of their energy and ingenuity one great mark of organizing ability is that inventions have been made and improvements have been so generally applied that despite increased cost of labor, coal and other materials there is but little if any increase in the cost of light and power to the consumer today over pre-war prices. Yet we have seen in this same period the greatest electrical expansion in our history. It is a magnificent achievement of the initiative and ingenuity of the men of this industry.

The nation which possesses the most adequate, the most reliable, and most mobile power and transportation systems will lead all others in economic progress. Because we are in possession of those two mighty and controlling tools, we are in that position today. Yet we are only on the way to greater things, for electrical science has now provided us with the means to still greater accomplishment.

We yet have a quarter of our homes without telephones; half of them without electric lights; two-thirds of them without radio. We will need 30,000,000 more electrical horse power in twenty years. Within that time our electrical industries must find thirty or forty billions of dollars in capital with which to have added the necessary equipment to our national plant.

The real purpose of all this development is, however, not to make self satisfying statistics nor to make new stocks and bonds. Its real purpose is this, that through more power we shall make a still greater saving in labor, increase the product of labor, and lessen the burden upon labor. Through even enlarged communication we shall increase our effectiveness in the direction of industry and commerce; we shall further the spread of intellectual ideas. Thus we gain in higher standards of living, wider enjoyment and comfort, to every fireside, which is the end and sole purpose of our economic effort as a nation.

All this has been the vision of that life of superlative usefulness—Mr. Edison. And the men who are today directing this great industry are more than ever before realizing its community purpose. There was a time when the application of electricity was viewed as merely a useful basis for promotors of stocks and bonds. That time has gone by. Today we have in the men of this industry, in its great majority, a vast vision of more purposeful accomplishment.

Electrical Communication

But to return to the problems before us. The key of further progress in all fields of electrical development might be stated in one word—interconnection. We interconnected the different communities in the nation by telegraph fifty years ago. We brought them into instant touch with all the world. We interconnected different towns and villages over the land by telephone twenty years ago. We thus enlarged the radius of personal touch of the individual to other individuals in every community.

Experimental interconnection of local radio broadcasting stations by telephone wires began only a few months ago. It is due to this that I am at this moment talking to people over thirty states. But few men have ever had this privilege. It yet lacks established system. Radio interconnection is the next and most vital step in the field of all human communication.

Radio

We have today six hundred local broadcasting stations; we all know that the local station can give better service than those far way. Our available wave lengths permit us to have from two to four nearby stations available to every listener. It is thus possible to have two to four alternate local programs at the same time. While programs of local origin will play a large part in broadcasting, yet radio will not have reached its full service until we have such interconnection of our local stations that we may also enjoy each night the product of our greatest artists and the thought of our leading men and women, and may participate in great national occasions.

All this will add not only great intellectual and stimulative force to the nation, but it will materially help to build up home life. For in the comfort of our own firesides, father can smoke, mother can knit, and the family

can make remarks upon the performance in terms not permitted in public places.

Our governmental relationships to this particular problem are complex in administration, simple in principle. We seek to preserve the ownership of the road through the ether as public property that we may maintain initiative by holding it a free field for competition; to keep alive free speech; to avoid censorship, to prevent interference in the traffic.

Future Power Development

But my main purpose tonight is to speak of the development of power. The next great step here also is interconnection. For interconnection is now the road of our great electrical march to more economical expansion. Indeed we have here before us a step of progress which will ramify into every field of our economic life.

This new vista in progress has been opened to us by the perfection in transmission of electric power up to two hundred or even three hundred miles and the higher mechanical efficiency of our generators up to 70,000 horsepower in a single machine. With these twin developments comes the opportunity to generate power in much larger and more economically located stations, to harness our water powers which were too remote for use even ten years ago and to bring them into the field of population. Herein do we have elements of often miscalled superpower.

We have in the United States today about six thousand separate power and lighting systems. To take advantage of these new forces we need interconnection of these isolated systems over large geographical areas so as to provide a sort of great reservoir into which these larger streams of power may be poured from central plants and from our greater water powers. Some interconnection has taken place, but in this large vision of our more recent engineering advances less than 10 per

cent of the systems are interconnected. We have many gains to make through this wider interconnection and central generation. From them we shall secure cheaper production costs, greater reliability, better utilization and consequent conservation of our coal supplies and larger utilization of our available water power.

Our thousands of minor isolated generation plants are each compelled to maintain reserve capacity in order to insure supply and reliability. Their very interconnection into large groups enables them to safely abandon a large proportion of their individual reserves and rely upon a central reserve. By their interconnection we secure at once a large diversification of use and a greater evenness of load by which the same size of generation equipment will take care of a much larger number of consumers. Taking the nation as a whole we do not today work our isolated plants to more than an average of 20 per cent of their capacity, yet with interconnection we can expect at least a 50 per cent load factor.

Beyond this again lies the better utilization of our water powers. By and large 75 to 80 per cent of our power east of the Rocky Mountains must be generated by steam even under the maximum development of our streams and rivers. The power that is available from our streams varies from winter to summer. The secondary power from this flood flow is of little value by itself, for light, heat and power must be continuous, but by pouring it into a general reservoir of consumption this seasonal supply can be used and the steam plants stand by for the low water season. Thus we can secure the full development and use of the secondary power of our streams and the use of it nearly doubles the amount of our available water power.

Such a power system renders the electrification of many railways possible and offers advantages to the large manufacturer and should ultimately displace thousands of our small steam plants and places reserves of power available for increasing demand.

We have made some progress in this direction, particularly in the southeast and the extreme west where power development has been mainly from water sources. Within a very short time the power lines from San Diego to Seattle will have been connected throughout. In the south we now have the most advanced superpower development in the nation extending as it does from Alabama across to the state of North Carolina. Yet as I have said we are only at the beginning. In the northeastern states where little has been done the annual savings are estimated at half a billion dollars against a construction cost of a billion and a half with an annual conservation of fifty million tons of coal by 1930.

The indirect results both human and material are even more important than these statements I have made would imply. For I have taken no account of the vast losses to industry and commerce by the actual interruption and threatened interruption of fuel supplies to our several hundred thousand independent steam units; no account of the relief to shippers from our already overburdened transportation and terminal facilities; no account of the increased production of our factories from cheaper power; no account of the larger extension of power into farm and home; in the reduction of physical labor, and the increase of comfort. Nor have I taken account of the great savings in our coal consumption; the lessenening burden upon transportation.

To secure the rapid adoption of these demonstratedly possible results is of profound public importance.

Governmental Relations

Now all this gigantic development raises hosts of problems in governmental relations. If we would secure these great benefits we need a wise statesmanship. From the very nature of the industry it is one where there must be a large measure of public control. Yet to draw the fundamental principles upon which these

relationships should be based is no easy task. They reach deep into our whole social conceptions.

When we come to the practical problems of government in relation to this problem the test lies in two directions. Does this act safeguard the equality of opportunity of our citizens? Does it maintain the initiative of our people? For in our answer to the first of these questions must lie the deadline against discrimination and exploitation and thus the protection of public interest, and in the answer to the second the deadline against socialism.

The economical distribution of power requires local territorial monopoly. Competing systems in power distribution in the same area mean an enormous duplication of capital and represent a tremendous waste in equipment and operation and in the end such duplication is a charge upon the consumer. But when we accept the principle of monopoly we at once must accept the principle of public regulation. There may be a few who still contend for the right to do anything they please but they are fast recognizing the inevitable, and there is no need for dispute. The principle of regulation has been recognized by our state authorities over the entire nation.

They have universally created public service commissions with wide regulatory powers in order that rates, profits and equitable distribution may be controlled. I am convinced that these bodies have demonstrated the feasibility of constructive regulation and the ability to secure that fine adjustment necessary to secure initiative and enterprise in development of power resources and at the same time to protect the public interest in equitable rates and profits. Otherwise we would not have had the great development of the last decade and the public would long since have rebelled.

Our governmental relations up until recent years, could be compassed by the sole authority of the separate states. But today through longer transmission and inter-

connection the state boundaries in power distribution are disappearing. (Moreover the control of much of our water resource lies in the Federal government and their distribution must move across state lines).

These new developments thrust upon us, new considerations of public relationship.

Unless we have a liquid flow of power into its national channels of consumption we shall have permanently a larger cost, less reliability of service and imperfect utilization of our coal and water resources. We cannot secure superpower development unless there is free flow of power across state lines. We have thus at once created at least a physical and economic interstate question. Our power development must now take a national and not a local basis.

There are time honored disputes over states rights with regard to water. Somewhat similar questions are being raised in many states with regard to water power. I am advised that no embargo could be constitutionally placed upon the free flow of power across state boundaries. Yet it is being attempted by some states. Moreover, discordant methods of regulation in different states may amount to economic barriers upon free flow and thus itself stifle development. I am alive to the practical situation among our people who live near water power sources, who believe they should have the first use of their cheaper water power. I believe that by constructive cooperation, this right can be satisfied and yet interconnection can be fully established.

Federal regulation is not the road to solution of these problems of interstate movement of power. I would regard any Federal regulation such as has been found necessary in transportation as a disaster to the development of our power resources. The fact is slowly emerging that the United States will eventually divide itself into several power districts each with its own problems. Problems relating to the origin of power,

problems of climate, problems relating to the character of industries and uses. No national regulation can supply that intimate knowledge of local problems which this industry requires. I believe that power development and distribution would find its greatest solution in coordinated state regulations among groups of states perhaps with voluntary assistance from the Federal government in securing this coordination. We need interconnection between state utility commissions where conflicting questions arise.

The formation of a committee under my chairmanship from representatives of the states from Maine to Maryland is a step in the direction of coordinated action in this the most important of our power areas.

Another of our public relationships to power lies in the Federal control of some part of our great water powers. Under the Federal Power Commission we have undertaken to secure the development of these great sources of power through private initiative under terms providing for the protection of the public and recovering to the government the right at the end of fifty years to resume ownership.

There are, however, special surroundings to a few of our great water powers which will require special action from a governmental point of view. We have special problems immediately before us in the development of the St. Lawrence and of the lower Colorado River, and in the development of Muscle Shoals. I have not the time to discuss these special cases beyond giving it as my opinion that where important interests of navigation, reclamation or flood control and international relations are involved, the government must be the stake holder through the erection by the Federal government of the primary works of construction despite its greater cost at the hands of the government.

But I have no taste for Federal government operation and distribution of power. We shall be able to

protect the public interest through the terms of lease or through the regulatory powers of our state commissions.

This brings me to another phase of public relationship which has received some discussion. We have some persons who insist that the Federal government should now undertake this superpower development. Not being a socialist I am not for it.

Much of this discussion comes from lack of understanding of the practical aspect of the industry. We find many people enthralled with the notions of "superpower" or "giant power" who conceive it a super imposed financial and industrial structure over all existing systems. At once they envisage a gigantic and grinding trust in the background. As a matter of fact no superstructure of this sort is possible. Superpower means interconnection of systems and larger central stations of coal or water scattered over the whole union. It is in daily progress before our very eyes.

Interconnection does not imply capital consolidation or the building up of great trusts. It implies the sale and resale of power from one utility distribution system to another and it implies cooperative action between utilities in the erection of central stations. It must embrace municipal plants as well as corporation plants. It implies no gigantic exploitation for that is impossible under state regulation of rates and profits.

But there are objections of more fundamental importance than this. As being one who believes that the progress of our nation can come only by preserving on one hand that vital initiative and enterprise of our people and on the other an equality of opportunity to all, I necessarily do not favor the strangulation of both by the hand of bureaucracy, and politics. No bureaucracy with a board of directors of five hundred eighty congressmen and senators would have made the electrical discoveries of the last thirty years or pioneered their

application. Our political system has not yet developed, and will not for generations to come, to a point where it will have either the capacity to choose skill or the assured probity to operate these implements. Our institutions will break down if we impose such burdens upon them.

We have seen nothing in our history to warrant us in the risk of stopping all progress by the deadening hand of the government. I know of no greater disaster that could come to the workers in this industry than to place their fate in the hands of political jobbery or stifling their individual opportunities through the leveling of bureaucracy which all this would bring about. At the same time the regulations of natural monopolies by the government is a vital part of the preservation of this fundamental equality of opportunity to our citizens, for if the use of this great weapon of power were to fall unrestrained into the hands of dominant groups, then equality of opportunity would also disappear.

If we have not the capacity to regulate these great tools in public interest we much less possess the capacity to operate them on behalf of the Federal government.

The Relation of the Industry to Regulation

Finally, I should like to say something upon the relations of the industry itself to the problems of government regulation.

It is true that there is always agitation for further governmental interference either because of real or fancied abuse. New abuses and new relationships are the inevitable growths of continued progress. New inventions involve new issues and new relationships. It is my belief that these abuses can be cured as they arise by the constructive action of the industry itself if it so wills. Many of these new problems cannot or will not be solved by the individual alone. They can only be reached through association in the industry as a whole.

In a recent address at Cleveland I endeavored to set

out the thought that it is through the growing strength of these associational activities of our industries, our professions, and our occupations that we have the greatest hope for the development of those high standards of conduct in relationships to the public, which in application will minimize the necessity for government intervention to correct abuse. I stated that I believed that in the transformation in the whole super organization of our economic life we are passing from a period of extreme individualistic action into a period of associational activities. In these associational activities lie forces pregnant with infinite possibilities of moral progress, possibilities of that large public vision and establishment of public confidence.

American business is never secure unless it has public confidence behind it, otherwise it will be a prey of demagoguery and filled with discouragement.

You embrace within your association directly or indirectly all of the elements of this great industry. Your association has shown great constructive abilities in the development of business ideals.

There is a noteworthy development in which your industry has led all others—and to a most remarkable extent. That is the placing of your new capital issues with your consumers and your employees. Nearly two million people now own the industry. Herein lies a new solution of our problems of the greatest promise. It is an entry into vital cooperation that almost makes one feel the touch of a new industrial world.

American business needs a lifting purpose greater than the struggle of materialism. It does not lie in some visionary and emotional crusade. It lies in the higher pitch of economic life and finer regard for the rights of others, through the organization of the great tools in our economic life, so that they may produce happier individual lives, more secure in employment, wider in possibilities of comfort and enjoyment, larger in possibilities of intellectural life.

THE WORLD'S PRESENT FUEL RESOURCES[1]

Three plans have been followed by those who have written on our fuel resources. The first I call the plan of the optimist. Presumably he is a widely known business man, and with his own eyes has seen vast resources of the fuel he is interested in. He knows of new discoveries having been made in (to him) unexpected places and, on interview, he maintains his own cheerful optimism by expressing belief in our boundless and inexhaustible resources and his confidence in the inventive genius of our people to meet any emergency when it shall arise. The people like to read such an interview; it saves them from all thought and worry on a subject they do not fully understand. No doubt fifty years ago there were lumbermen who took the same view of our timber resources which today have almost disappeared.

The second plan is, of course, that of the pessimist. He can figure the exact extent of the seams of coal we are mining under the conditions of today, and point to the oil fields we have exhausted. Knowing the approximate extent of these reserves, he can come to the true enough conclusion that within a comparatively few years they will be exhausted, at which time, of course, our modern industrial civilization based on power through fuel will have to cease. The weakness of these estimates is failure to recognize that the economic principles of cost and profit are the major factors in determining what is a resource. For example, no one in this country today considers a deeply buried twelve-inch seam of coal as an asset or resource. The cost of producing fuel from such a seam would be prohibitive, and yet in Belgium the economic situation covering the cost of labor and the selling price of fuel is such that a twelve-inch seam of coal is mined from great depths at a profit.

[1] By E. A. Holbrook, Dean, School of Mines, Pennsylvania State College. Annals of the American Academy of Political and Social Science. 111 : 203-11. January, 1924.

Midway between the first and second plan comes the third plan of estimating our fuel resources. This plan is based neither on optimism nor on pessimism, but is a result of the study of all known factors by competent men, and a setting forth of actual figures based on all these factors. Under this heading come the wonderful and exhaustive estimates of our fuel resources that have been made through the United States Geological Survey, particularly by Messrs. Ashley, Campbell and White; the work for the Smithsonian Institution by Wyer and also by Gilbert and Pogue; and the results of figures compiled by engineers and geologists to be found in the Transactions of the American Institute of Mining and Metallurgical Engineers and in other places. It is largely from these sources that this paper has been compiled.

It is self-evident that if we have fifty acres of coal and we mine one acre each year, the coal will be exhausted in fifty years. Nature will not renew it as in the case of growing crops. Therefore, we may for all natural fuels use the term exhaustible resources. If in turn, by exact geological reasoning, we limit the boundaries of each of our coal beds, we can certainly arrive at a definite estimate of the amount of this exhaustible resource remaining. The same line of reasoning may be applied with a greater or less degree of accuracy to petroleum and natural gas, our other natural exhaustible resources. At this point, however, the economic factors come in strongly. How about the coal beds so impure or so thin that we cannot mine them at a profit today? If coal were twice as valuable as at present or the cost of mining were reduced—say by one-half—could we not employ as a fuel many coals that we cannot consider as resources today? And by the same reasoning, could not many oil sources be made to produce their quota of oil?

Another uncertain factor in the estimation of resources is the forecasting of future consumption. If the rate of increase in consumption of fuels which we have

had for the past fifty years were to continue for the next one hundred years, the production would reach almost unbelievable figures and the world would be hard put to for fuel. Again I look for the economic factor of cost of power to progressively lessen our demand and so prolong our resources.

More and more I am of the belief that future historians will recognize that James Watt (1736-1819), by his invention of the modern steam engine, accomplished the greatest revolution in the lives of nations and peoples since the beginning of Christian times, of greater influence than the bickerings of kings and princes, and in fact, by making it possible for several people to exist in space where only one had existed before, of paramount importance to you and to me.

Modern industry and civilization owe their being to power, and the way to power was led by Watt. Before that time the life of the majority of people was what we would call existence. A man was comfortable only to the extent that man power could provide necessities and comforts. A servant or slave exerting his energy or power on behalf of the master could produce enough for his own existence and a little excess for the master. Do you know that, figured on the fuel-developed power of this country today and converting this into man power, each of us, on the average, has an equivalent of thirty servants or slaves of the old days working to make us comfortable, through light, heat, transportation, food and materials, production and amusements!

This power is nothing but the utilization of the energy stored up in our natural fuel resources. Let us, therefore, examine them carefully.

1. Coal

The coal resources of the world was the subject of a careful inquiry made by the Twelfth International Geological Congress, held in Canada in 1913. In brief,

they found that the land area of the world had been studied with sufficient exactness to determine the areas underlaid with coal beds, and that for the major part of these areas sufficient exploration has been conducted to determine the number and thickness of the coal seams with fair degress of accuracy. In these areas seams one foot in thickness or over, within four thousand feet of the surface, containing coals of present or probable future economic value, were called actual reserves; coals of economic thickness occurring more than four thousand feet below the surface were considered possible reserves; and coals of both classes, which by reason of location could not be subjected to reasonably accurate estimates, were considered as possible reserves. While owing to differences in method of estimation by different countries reporting, the table following of "Estimate of the Coal Reserves of the World" is not exact, yet it gives the most complete estimate available:

ESTIMATE OF THE COAL RESERVES OF THE WORLD

(*In million tons*)

	CLASS A ANTHRACITE AND SIMILAR COALS	CLASS B AND C BITUMINOUS COALS	CLASS D LIGNITE AND OTHER LOW-GRADE COALS	TOTALS
Oceania	659	133,481	36,270	170,410
Asia	407,637	760,098	111,851	1,279,586
Africa	11,662	45,123	1,054	57,839
America ...	22,542	2,271,080	2,811,906	5,105,528
Europe	54,346	693,162	36,682	784,190
	496,846	3,902,944	2,997,763	7,397,553

In round numbers, seven and one-half trillion tons of coal stand between the world and coal exhaustion. Compared with the world's present yearly consumption of about one billion, two hundred million tons, it indicates that at the present rate of consumption this earth has enough coal for seven thousand years, and that with

an expanding rate of consumption we can figure the supply to last anywhere between two hundred years and seven thousand years, depending on the ratio of increase used. To me, the striking thing on this estimate is not that any definite period has been set for the exhaustion of our coal supply, but rather that by accurate and definite methods a boundary has been set on our supply of coal and its limits brought into understandable figures.

America's Reserves Compared to Other Countries

Observe, please, that America has almost 70 per cent of the world's reserves. The United States alone has over 50 per cent of the world's reserves and Canada most of the remainder to make up the 70 per cent for America, since Mexico and South America have such small reserves that they hardly enter into the calculation. Another observation from the detailed estimates is that the United States has over one-half the world's supply of coal, the British Empire about one-quarter and the rest of the world the remainder.

Of the industrial countries of western Europe, Belgium has the smallest resources, France next, Germany next and Great Britain the greatest. Even with this lead, Great Britain, having closely mapped and estimated every possible seam of coal within her borders cannot see with present ratio of increased use more than three hundred years of industrial life of the present character. Even with present production as a basis she has left only five hundred and eighty times the 1913 output. McCulloch and Simpkin in an English book on coal [1] conclude that

> Our future is dependent on (1) mining of coal from the earth in the most economical way; (2) working of all power plants on a scientific basis to obtain the greatest power and improvement; and (3) making provision for a suitable smokeless fuel to avoid the wastes caused by burning the raw fuel.

[1] From McCulloch & Simpkin, "Low Temperature Carbonization of Coal."

Of the other countries of Europe, Czechoslovakia and Austria have some coal, but the remainder have not developed as industrial nations solely because they have no considerable supplies of coal within their borders.

Shortly after the war, C. W. Barron, editor of the *Wall Street Journal,* after a visit to Europe, made this significant statement:

> The United States is great, not because she produces the greatest corn or cotton crop of the world, but because she has the mines to produce seven hundred million tons of coal per year or more, indefinitely.

A plentiful supply of any substance makes for carelessness and waste both in production and utilization. Here we are in possession of more than half the essence of the world's industrial civilization. Is the fact that it will last us longer than the coal in possession of the other nations of the earth any reason why we should treat it carelessly?

Some of you will ask, "How about China; has she not enormous reserves? We have read of them in the papers." Let me say that both Asiatic and European geologists have a good approximation of China's coal reserves, and after talking with American engineers who have examined various deposits there, I venture the opinion that the estimates of the International Geological Congress have not understated them.

The extent, purity and ease of mining our American coals are a source of wonderment and envy to every foreign geologist and engineer with whom I have conversed.

Necessity for Conservation

The United States Geological Survey has lately (1920) issued new estimates of our own coal reserves by M. R. Campbell. He estimates an original coal tonnage within the United States of over three and one-half trillion tons, of which eighteen and one-half billions or

½ of 1 per cent have already been mined or lost during the process of mining. If we assume the present rate of consumption there will be enough to last four thousand years. On the other hand, if the present rate of increase in our coal consumption should be maintained, the supply would probably not last one hundred years. The true life is between these extremes depending upon the real rate of increase that future years shall bring forth. It is instructive that the actual rate of increase in the decade since the first estimates were made has been greater than the estimated increase.

But we cannot dismiss our coal situation thus lightly. Examination shows that over half of our reserves are the sub-bituminous and lignite coals of the west, which today we look down upon as being of low grade and of mostly local value only.

It is a fact that, even with mining continued on its present basis, less than one hundred years will see the greater part of our anthracite gone, and with the best bituminous seams, such as the Pittsburgh seam of western Pennsylvania, approaching exhaustion.

While Pennsylvania produces more coal than any other state, her reserves are less than those of several other states. The Pennsylvania reserves have simply been developed more.

No one can study the figures of the Survey without becoming convinced that conservation through the best production and use of our coal should be practiced now. For all we know, population and many industries will continue to migrate in the direction of cheapest fuel, and the exhaustion of any of our coal districts would therefore cause incalculable losses in present property values over large areas. Already, according to H. C. Porter, "The fuel bill of the United States in 1920, if apportioned among the wage earners, would constitute 15 per cent of the average income." Let us regard more highly this fuel key to our prosperity and industrial life.

2. Petroleum

The second great fuel resource is petroleum. The industry is generally supposed to have started with the drilling in 1859 of the Drake well in Pennsylvania. As a matter of record [1] the production of the Baku (Russia) oil field in 1819 was about thirty thousand barrels, and it is recorded that in 1797 there were five hundred twenty producing oil wells in Burma with a yield of approximately six hundred thousand barrels per year.

That petroleum in a given field is a short-lived and declining resource is truly given by the life history of our Pennsylvania fields. Beginning in 1859 and rising to a maximum of about thirty-one million barrels in 1891, it has steadily decreased to seven and one-half million barrels in 1921, in spite of great price increases as an inducement to exploitation.

The possible oil fields of the United States have been carefully mapped and by methods already proven surprisingly accurate, the United States Geological Survey has estimated the recoverable reserves at about nine billion barrels, or at present rate of production not greater than twenty years' supply. This does not mean that we will be without petroleum and petroleum products within this time, but that we shall become, in order to eke out our residue supply, an importing nation for the greater part of our needs with an increasing price depending on our ease of access to the foreign fields.

I know some of you will say, "Why, there is an oversupply on the market right now; a big new California field has come in and not for years has gasoline been as cheap as it is today." All true, but it does not change our premises. On the whole, each year is seeing the finding of new fields in the United States more costly. A few millions of barrels excess oil from a field being drained in haste does not prolong our supply or change

[1] From report of Subcommittee on Petroleum. Mining and Metallurgical Society of America. 1923.

greatly the estimate of reserves. Within our normal lifetime we will be importing the bulk of our natural petroleum products.

Value of Improved Methods of Recovery

Of foreign fields I am optimistic. The Subcommittee on Petroleum of the Mining and Metallurgical Society of America has recently reported

> The oil resources of the world are much larger than the recently published estimates, and improved methods of recovery should enormously increase the difference. Petroleum may occur in almost any sedimentary rock, and the sedimentary rocks found in the United States are but a small part of the sedimentary rocks of the world as a whole. It is only that the sedimentary rocks of the United States have been more extensively developed for oil. It follows that the supply of petroleum in the United States is relatively more nearly exhausted than in the other countries.

From these facts, it is apparent that our government should give every encouragement and protection to American oil companies now endeavoring to locate supplies of petroleum in foreign fields.

A most instructive side-light on the prolongation of our oil supplies has recently come to my attention. It is well known that our present method of pumping oil from a well exhausts only from 10 to 30 per cent of the oil in the sands at the bottom of the hole. We get only the excess that has been squeezed out of the rocks

In Alsace during the war the Germans mined oil sands to recover petroleum. Do not confuse this with the production of oil from oil shales, which will be considered later. Presumably the Alsace oil sands produced 20 to 30 per cent of their oil by drilling and pumping. It was reported that by sinking shafts and driving galleries in the oil sands, 30 to 40 per cent more of the oil drained into the galleries. The work is being continued by a French company who plan on treating the sands on the surface for the remaining oil.[1] Does this not point

[1] From communication from G. S. Rice, Chief Mining Engineer of the U. S. Bureau of Mines.

the way to further utilization of our partly exhausted oil sands when the price of petroleum products will admit?

Shale Oil

We have all heard of the possibilities of extracting petroleum from our oil shales. Briefly, the facts are that in Scotland there occurs a shale rock impregnated with bituminous matter. This rock on being subjected to a distillation process yields a product having many of the properties of petroleum and is known as crude shale oil. Whatever the nature of this substance, its occurrence in the rocks is different from that of petroleum. With petroleum the oil flows from the porous sands by pressure alone, while the substances in the oil shale seem to become like petroleum only upon heating and distillation.

Where the price of natural petroleum products has been high, as in Great Britain, it pays in a limited way to mine and distill this shale as a substitute for some of the uses of petroleum. We have discovered that this country has enormous reserves of oil shale of similar character. For example, it has been estimated that northwestern Colorado alone contains enough shale to produce forty billion barrels of oil, or over four times our present petroleum reserve; that Indiana has a reserve from similar materials of one hundred billion barrels, and that Utah, Wyoming, Kentucky and other states have such enormous reserves that they constitute a resource in shale oil almost without limit and sufficient to last this country for hundreds of years. This is probably a true estimate of a reserve that will come into the market gradually as the price of petroleum products increase. It is safe to assert that, up to the present time and with any prices for oil products comparable with those of the past few years, no shale oil has been or will be produced in this country on a commercial basis. The shale must bear the cost of mining and refining before its product is on a cost basis comparable to the crude

petroleum. Discounting yearly fluxations, the future must see a steadily increasing price for gasoline and other petroleum products. When these reach two or three times their present price, oil from shale should begin to form a commercial product. The main point is that of all the substitutes for petroleum products that have been proposed, the oil shales constitute the only reserve whose quantity is sufficient to supply the great quantity of petroleum products called for. Other proposed substitutes disappear when measured in terms of a yearly demand of half a billion barrels.

In 1922 the world's petroleum needs were 850 million barrels, of which the United States consumed 551 million barrels, or 65 per cent. Of this roughly three-fourths goes for the production of power as a substitute for coal and one-fourth as a motor fuel. It takes, for power purposes, about four barrels of oil [1] to equal a ton of coal. Therefore, the whole of fuel oil consumption replaces but one hundred million tons of coal, less than one-sixth of our present production. It seems reasonable to summarize from the facts presented that oil will not compete with coal, except for special purposes and in certain localities where low freight rates, smaller bulk as compared with coal or comparative ease of control, make oil burning feasible. From a country-wide or world-wide situation, it is not a competitor of coal, but rather a supplementary fuel whose proportionate share in making the world's power is not likely to increase.

3. Natural Gas

A few years ago I accompanied a French naval mission through the Pittsburgh industrial district. The head of the mission informed me that the most marvelous thing he saw there was a natural gas well. Drawing gaseous fuel from nature's storehouse without effort

[1] Two barrels of oil used in a Diesel engine are equivalent to one ton of coal.

was to him like a native of the tropics sitting under a cocoanut tree and waiting for his food to be dropped to him.

Do you realize that we are the only nation that has been so richly endowed with this most convenient of nature's fuels? And how we have wasted it! West Virginia, Pennsylvania and Ohio, the great producing and consuming centers of the east, have realized almost too late that this fuel is primarily intended for domestic use, especially as a means of doing away with the city smoke nuisance.

As a resource, the natural gas fields east of the Mississippi River and supplying many of the large centers of population roughly west of the Allegheny Mountains are on the decline. Fifty years of production and waste has seen the supply exhausted in many fields, and all charts examined show a constantly diminishing supply being sold. An instructive illustration of the accuracy with which a trained geologist may forecast the possibilities of a natural gas field was brought out during the McKeesport, Pa., natural gas boom in 1919. Here a large and profitable well had been found and many companies were formed to drill similar wells to the supposedly inexhaustible resource. The state geologist of Pennsylvania, Dr. George H. Ashley, after an examination of the data available, stated publicly that the wells would be exhausted by a certain date only a few months in advance. Certain citizens of that vicinity ridiculed him. His prediction was verified with an error of less than a week.

West of the Mississippi, particularly in Louisiana, Texas and Wyoming, there are considerable resources of natural gas. They are, however, not important as a fuel supply for our northern and eastern centers of population. The longest transmission pipe line for natural gas is about 340 miles and it has not been a success, owing to the high cost of pumping and maintenance. Generally speaking, the exhaustion of our supplies of

natual gas as it is being used today is a matter of a generation only.

This, best of all fuels, having twice the heating power of manufactured gas, should not be made to compete with coal as an industrial fuel, but should be saved and utilized for domestic purposes only.

4. Water Power

Water power is a fuel resource just as clearly as is coal, since more than two-thirds of our production of coal is used for the production of power. Considerable space has been devoted lately in the newspapers to extravagant claims as to the days when we should heat all our homes and derive all our power from this "white coal." The facts are that the writers do not realize how much power is derived from coal today and how little is probable from water power, present and future.

The United States Geological Survey, after an exhaustive survey of all the streams of the United States, has told us that if all their energy were utilized, we would have 46 million horse power at our command, and that of this about 28 million horse power is all that could be developed without unreasonable expense. Today we use 49 million horse power alone, generated mostly from coal to supply our engines, factories, mines and cities. If every bit of electrical energy possible from our streams were used to heat our houses, a few simple calculations show that it would heat about 4 per cent only of the homes in this country.

To add to this difficulty 79 per cent of our undeveloped water power is on or west of the Rocky Mountains, far removed from our centers of population.

Our water power as a whole is comparable to the water power of other nations and parts of the globe having similar area.

The logical conclusion must be, therefore, that valuable as are water powers for local development of power

and with consequent saving of our fuel resources, they can never replace the great and growing demand for power that must be satisfied, if at all, through the coal resource.

5. Vegetable Fuel Resources

No account of the world's fuel resources would be complete without a reference to the possibilities of wood and other vegetable products as a possible source of fuel, either by burning direct as with wood, or that obtained through fermentation and distillation as the production of the alcohols from potatoes and grains. These forms of fuel share with water power the advantage that they are replaceable; that is, new crops may be grown or new rains replenish the supply, in contrast to the irreplaceable mineral fuels.

Wood has been and will long continue to be a fuel of local importance. It takes roughly two cords of wood to equal a ton of coal. In other words, more than a billion cords of wood would be necessary each year to replace our present coal supply. Since an acre of woodland will produce somewhat less than a cord of wood per year, it would take roughly two-thirds the land area of the United States devoted to scientific forestry to supply wood equal to our present coal demand. The present yearly cut of timber in the United States for all purposes is 22½ billion cubic feet. Translated into cords and assuming it all to be used as fuel, it would replace only one-fifth of our yearly production of coal. Thus the impossibility of considering in any way the substitution of coal by wood. As long ago as 1817, when our Pennsylvania iron industry was in its infancy, the Pittsburgh Chamber of Commerce, becoming alarmed because the forests had disappeared through being made into charcoal for the iron furnaces, sent a commissioner to England to investigate the report that a product of coal could be used for the same purpose.

Much the same story as for wood can be told for the grains. Not long ago it was established in Iowa that as a fuel corn at 10 cents per bushel was equal to coal at $5.11 per ton; in other words, coal would have to be $40.00 per ton to consider using corn as a substitute at the present price of corn. And again, the future is going to see our farm products needed for food more than for fuel.

In general, while all of these possible vegetable substitutes for coal and petroleum products are interesting in a local way, they can never replace the enormous tonnages of the mineral fuels that are needed today for our modern industrial life.

Résumé

Coal is and must continue to be the foundation of our industrial civilization and the basis of our organized life. It is a non-replaceable asset whose supply has been bounded by a term of years comparable to our Christian era. For all we know today there is no substitute to furnish the vast quantities of power increasingly demanded. Common decency for the coming generations demands a rational program of conservation, production and utilization.

Petroleum is a supplementary fuel only, whose supply and cost is, if measured over a generation, more uncertain than that of coal. Higher prices and more restricted uses are forecasted within a few years by the evidence now at hand. Water power is valuable but inadequate.

Vegetable products fuels, although possible for many minor uses, fail utterly to meet the need when figured on a comparable tonnage or quantity basis.

Coal, then, is the basic fuel of the future, and the problems of its production, distribution and utilization are problems that must be met and solved if you and I and our posterity are to continue in our creature comforts and life of an industrial civilization.

GIANT POWER AND COAL [1]

Giant power signifies not only a mammoth scale but a widely integrated electrical service and one benefiting largely from certain fundamental economics such as by-product recovery at present, either not practiced at all or practiced only at isolated points. Giant power also implies definite social ends such as furnishing current generally to the small user, including both the farmer and the manufacturer removed from the congested centers of population, and this at rates making such use economically feasible.

Governor Pinchot and the legislature, which under his leadership authorized the appointment of a Giant Power Survey Board, hope through its activities and reports to make a substantial contribution to the conservation of national resources. For while we contend that electrical technology has reached the point where electrical power can be brought into almost universal use, we just as insistently demand that the easily preventable wastes resulting from our present methods of generating and distributing electrical current shall cease.

Economy of Water-Power Developments

Pennsylvania is primarily interested in this new phase of the conservation movement because of the desire to safeguard her vast coal deposits. For while Pennsylvania is supplying today practically 40 per cent of the coal required for the nation's use, our deposits are far from inexhaustible. In fact, the end of our coal is in sight—well within 100 years—unless we can put a stop to some of the more flagrant wastes especially in its use for power purposes. Other coal-producing states—such as West Virginia and Illinois—have relatively even more to gain because of the larger deposits yet remaining in the ground. In recent years we have come to appreciate

[1] By Morris L. Cooke, Director, Giant Power Survey, Commonwealth of Pennsylvania. Annals of the American Academy. 111 : 212-18. January, 1924.

the economy of water-power developments. It is not yet understood, however, that few water powers can be effectively utilized except as adjuncts to coal-burning power stations. Therefore, with each step in the integration of electrical facilities, a further inducement to water-power development is afforded, a further conservation of natural resources made possible.

As Governor Pinchot has pointed out, there is one basic development that paves the way to a more or less immediate realization of the new electrical day. As Pennsylvania is not much more than 300 miles wide from east to west, the distance factor in electrical transmission has for us been all but eliminated. The losses in passing current from one end of the state to the other are negligible in view of the economics. We are now in a position to generate current either by water power or steam power wherever it can be manufactured with the least expenditure of effort and material and then to transmit it to the point of use. This one fact requires an absolutely new synthesis of our energy resources and of our energy requirements. It makes feasible the concept of the pool of power—a far-flung network of electrical facilities into which energy in the form of current can be poured from whatever the source and out of which energy in the form of current can be taken to meet any need. This wide-reaching geographical distribution means the utilization of the supply for highly diversified uses and this involves the economies that go with an even demand.

Coal Production and Use

Before proceeding to an examination of some of the bearings of giant power on coal, it will be well to have before us a few statistics as to the production and use of coal. The United States produced in 1922

422,268,099	tons of	Bituminous coal
54,683,022	" "	Anthracite coal
476,951,121	"	Total

This was a year of rather low activity, for in the present year, up to October 20, there was produced

445,801,000	tons of	Bituminous coal
77,343,000	" "	Anthracite coal
523,144,000	"	Total

Of the 1922 total, there was actually loaded for shipment away from the mines

383,677,407	tons of	Bituminous coal
46,003,699	" "	Anthracite coal
429,680,106	"	Total

Thus there was shipped away about 90 per cent of that raised to the surface. The balance is largely accounted for by coal coked at the mines and local sales.

In 1922, Pennsylvania raised 113,148,308 tons bituminous coal, or 26.8 per cent of that raised in the United States.
In 1922, Pennsylvania raised 54,683,022 tons anthracite coal, or 100 per cent of that raised in the United States.
In 1922, Pennsylvania raised 167,831,330 tons total coal, or 35.1 per cent of that raised in the United States.

Of the amount of bituminous coal raised from Pennsylvania mines, reverting to the latest available government figures, those of 1918, 40 per cent was used in the state (of which a little less than one-half was shipped away from mines), 18 per cent transferred to railroads for railroad use, 6 per cent to New York state, 3 per cent to New Jersey and 4.5 per cent to New England. The balance went to tidewater for export, for bunker fuel, or to the western states principally by way of the Great Lakes.

In 1918 the total bituminous coal used in Pennsylvania was 79,893,062 tons, while New York state used 20,467,028 tons and New England 20,835,000 tons. Of the bituminous coal reported in 1918 as consumed in New York state, 11,500,000 tons or 55 per cent of their total supply came directly from Pennsylvania mines. Of that used in Pennsylvania about 32,000,000 was

coked at the mines, leaving 47,000,000 tons used as coal for industrial, railroad and domestic purposes.

Part of Giant Power Program

In order to visualize what may prove to be the influence of giant power on coal, let me suggest quite tentatively a few of the planks in the giant power program—without at this time pausing to present supporting data.

1. *Large-sized stations*—say not smaller than 650,000 H.P.;
2. *located at or near the mines* and supplying current to
3. *a trunk system of transmission lines* reaching 220,000 volts with large capacity to carry power long distances
4. *An integral transmission and distribution system*
5. *By-product recovery* in some form
6. *The furnishing of current to the rural population*
7. *Trunk line railroad electrification*
8. *Radical reductions in rates* especially to the smaller consumer and at least in proportion to the reduction in costs.

Interstate Control

We can frankly admit that this program—actually now in process of being realized—while it affords the only route to the cheapest power and therefore to the most widespread use of power—also creates a monopoly and a monopoly of tremendous import. This will be true, however, whether under public ownership or under regulated private ownership. It is obvious that the control in the public interest of such developments under private ownership implies a load on our system of state regulation of public utilities which it has never yet been required to carry.

As complete integration into a single inter-connected electrical system is approached in the northeastern United States, it is probable that state regulation, as we have known it, will become increasingly ineffective.

Inasmuch as giant power cannot know state lines, there are reasons for anticipating regulation by pact be-

tween two or more states in order to provide regulatory areas corresponding with natural pools of power. There appears to be little reason for urging Federal regulation. Therefore, control by areas to be determined largely by technical considerations, such as the effective transmission distance, may prove to be the answer.

Relative Importance of Steam and Water Power

Any consideration of the feasibility of such an interstate pact, mutually binding on Pennsylvania and any of her sister states, inevitably directs attention to the relative importance of steam power and water power as factors in our future energy supply. We can admit gross negligence in our failure to develop our national heritage of water power and yet fall into grave error if we fail at the same time to point out what appears to be the lesser importance attaching to water power as compared with steam power. In fact, as time goes on and the community learns to use mechanical power more freely, this disparity will become greater.

Only figures can visualize this situation. And yet one uses figures with every reservation in stating a problem involving so many variables. In the northeastern United States the principal water powers are found in New York, Pennsylvania and New England. The situation within this area can be approximately expressed as indicated on the following page.

Available Water Power in United States

Thus it will be seen that the only undeveloped water powers which can at all vitally affect the power situation in this district are to be found in New York state and have to do principally with the proposed developments of the Niagara and St. Lawrence Rivers.

The present development of the Niagara River is limited by treaty to 20,000 cubic feet per second on the

American side; and practically the whole permitted flow is being utilized, but with considerably less than maximum efficiency.

The maximum available head at the Falls from the head of the rapids to the level of Lake Ontario is 310 feet. If we consider 305 feet, which is the head actually achieved by the publicly owned development on the Canadian side, as possibly available, and 80 per cent of potential energy as deliverable at the station outlet, the maximum power possible would be about 600,000 H.P. Under present installations, probably not one-half of the total head is utilized, so that actual present power developed on the American side is not in excess of 270,000 H.P.

Installed steam power:		
New York		3,750,000 H.P.
New England		3,500,000 H.P.
Pennsylvania		5,500,000 H.P.
		12,750,000 H.P.
Developed water power:		
New York		1,250,000 H.P.
New England		1,300,000 H.P.
Pennsylvania		150,000 H.P.
		2,700,000 H.P.
Undeveloped water power:		
New York		4,000,000 H.P.
Niagara	2,000,000 H.P.	
St. Lawrence	800,000 H.P.	
Delaware	150,000 H.P.	
Interior Rivers	1,050,000 H.P.	
	4,000,000 H.P.	
New England		400,000 H.P.
Pennsylvania		1,000,000 H.P.
		5,400,000 H.P.

If the entire flow of the Falls could be utilized in the same divergence proportion between the United States and Canada as now, the United States could utilize, out of a total natural mean flow of 212,000 cubic feet per

second, 75,714 cubic feet per second which would give a maximum efficiently developed power of not to exceed 2,100,000 H.P.

The St. Lawrence River from the end of Lake Ontario to the limit of United States boundary may yield a maximum of 1,600,000 H.P. If one-half is assigned to the United States then 800,000 H.P. would be available on the American side.

Despite Water Power New York State Is Increasingly Dependent on Coal

In New York state in 1922, the Public Utilities generating electricity by steam used approximately 4,600,000 tons of coal, all of which was imported from Pennsylvania, Ohio, Maryland and West Virginia. This coal generated nearly 6 billion horse-power hours, from an approximate capacity (ignoring standby or surplus) on a 40 per cent load factor of 1,675,000 H.P.

This means that the complete development of the St. Lawrence River project could reduce the coal required to be brought into New York state for the present use of the electric utilities alone by only about one-half. To eliminate the need of importing the balance of the coal required merely for these electric utilities, the divergence of the waters of Niagara Falls would have to be increased from the present allowance of 26.4 per cent to 65 per cent. If this additional power were utilized with the present partial head, it would take practically the entire flow of the Falls.

Thus it will be seen that if New York state today had all her water powers—both those available and at all likely to become available—fully developed, she would still be dependent on the states to the south of her for an amount of coal representing a very considerable part of her energy supply. With the increase in the use of current for domestic, agricultural and industrial purposes, New York's dependence on coal

will constantly become greater. Of course what is true of New York is even more true of New England, because her water powers developed and to be developed represent a much smaller proportion of the total present use of power. In this connection it is interesting to note that the Ontario Hydro Electric Commission, now operating almost exclusively with current supplied from Niagara and other smaller water powers, foresees the complete exhaustion of hydro power by 1932. After that year it is expected further developments will be dependent on current derived from coal-burning stations.

Necessity for Standards of Fuel Economy

Now to haul the needed coal to New York state rather than to transmit the current involves not only a heavy burden of additional fuel for transport purposes, but almost inevitably means that after the coal reaches New York state it is burned in a multitude of plants widely separated and for the most part inefficient—requiring, as in 1922, nearly three pounds of coal per horse-power hour. The alternative is to be connected up to a suitable number of giant power fuel-consuming plants practicing by-product recovery located in or near the coal fields in Pennsylvania or West Virginia and selling energy on the basis of using something less than one and one-half pounds of coal per horse-power hour. Guy E. Tripp, Chairman of the Westinghouse Board, was recently quoted as saying:

> A 1,000 H.P. generator such as is used for service in a small town requires about four pounds of coal to produce a horse power for one hour. But a 50,000 H.P. generator can produce the same amount of power for less than one and one-half pounds of coal.

Will New York continue to haul coal to wastefully burn it, rather than tie in to the northeastern system in full cooperation with all sources of economical power contributing to the same pool of power?

The recent overwhelming defeat at the polls of the Ferris Amendment to the New York State Constitution suggests that the voters of New York are not indifferent as to the method by which giant power is to be obtained. Nevertheless, it appears to be an ultimate economic necessity for the Empire State.

The great differences recorded as between different electric stations in the matter of the efficient use of coal suggests that the day cannot be far distant when our state commissions will find it advisable to set up standards of fuel economy. As the fuel item represents roughly three-quarters and over of the whole cost of making current the inducements to such regulation are obvious.

Suggested Electrification of Railroads

Nowhere are the effects of large-scale electrical development likely to be more marked than on our transportation systems. And perhaps the largest single factor in this will be the diminishing of the coal load. The railroads themselves now use 30 per cent of our coal production, and one-third of their freight load is coal with most of the cars hauled back empty. Of course on some of our Pennsylvania roads this percentage is much higher. Baum has estimated that the cost of maintenance of electric locomotives will be about 50-60 per cent of that of steam locomotives and he argues that, since the railways of the United States use 175,000,000 tons of coal per year, complete electrification might effect a saving of 100,000,000 tons a year.

Practically all our trunk line railroads are confronted with the necessity of materially increasing facilities if they are to keep pace with increased freight offerings. This disparity between tonnage offered to our railroads and their capacity to handle it expeditiously is likely to reach the critical point during the next boom period. The least expensive and most logical way out apparently

lies in electrification, making possible the use of the more mobile electric engine and making it unnecessary for every train "to carry its power supply on its back," as Bruère has expressed it.

Further aid will come as energy is transmitted everywhere over wires through reductions in the coal freight load, thus making room for a larger volume of higher grade commodities. As Herbert Quick has pointed out, we Americans are attempting something absolutely new in nation building in that our whole social system is dependent on the free flow of a vast freight and passenger traffic over great distances—east and west, north and south. Our war-time experience gave indisputable proof that our present rail facilities may easily be taxed to the breaking point; and further, that more cars and more steam engines may easily make the situation worse. Electrical motive power in place of steam on the railroads and a community supplied with energy generated at or near the mines rather than by coal hauled over the railroads seems to be the answer.

Unified Power System an Efficiency and Conservation Measure

Obviously this large-scale electrical development will vitally affect the way in which the mining of coal is carried on. Throughout this volume are references to the irregularity in the demand for coal and the consequent speculative character of the industry and intermittency of employment. A giant power system may easily make an energy budget both by states and regions possible for the first time. Within reasonable limits a unified power system will enable us to determine in advance what the demand for power is going to be. It is obvious that such a budget would also enable us to stabilize production and employment at the mines.

The anthracite industry seems to offer a rough illustration of this fact. Up to the early years of this cen-

tury, production and employment in the anthracite fields were notoriously more intermittent and irregular than present production in the bituminous fields. With the development of the anthracite monopoly, the operators were able to determine in advance what the minimum or firm demand for anthracite was going to be. Once they made this determination they limited anthracite production to approximately 80,000,000 tons a year, of which over 70,000,000 tons went into the market. As a result of this crude budget, production and employment in the anthracite fields have steadily risen from the neighborhood of an average of approximately 200 days a year to approximately 270 days a year.

The great aim of giant power is not so much to increase the rate at which we mine coal, but rather to increase the efficiency of the transformation of coal into power. The importance, therefore, of an energy budget, which seems possible only under the conditions of a unified giant power system, from the point of view of energy conservation as well as of stabilizing employment in the mines, is clear. All this seems to emphasize the importance of the storage of coal—but for power purposes rather of storage at or near the mines as contrasted with storage at points of distribution or storage in the consumers' bins. The consumption of coal at the mines for the production of power will have an influence on the quality of the coal prepared for shipment. The ability to use lower grades of fuel in the giant power plants will provide a use for such fuel without attempting to pass it out to the public, the practice of which is so apparent whenever a shortage of coal in local markets occurs.

Ways and Means Toward Unification

We can concede that unification must be the central theme in the energy supply of the future—even of the immediate future—and yet see a number of routes by

which it may be brought about. It is perhaps fortunate not only for Pennsylvania, but for the nation, that we have right here in this state all the elements that must be woven into the fabric of a giant power system—water powers, vast coal deposits within workable access to adequate condensing waters, large centers of population removed some distance from the water and coal sources of energy, great areas of prosperous farming territory with a fairly high average number of farms per mile of road to be transversed with electrical lines, and above all, an intensive and diversified industrial activity that will support a large-scale electrical development. A reasonably full application of the principles of giant power appears to be just below the horizon. Once applied to Pennsylvania the broader logic of the application to a territory not bounded by state lines will be clear.

STATEMENT OF SECRETARY HOOVER TO THE SUPERPOWER CONFERENCE, OCTOBER 13, 1923

I have called this conference with the approval of the President for a preliminary discussion of what cooperative steps Federal and state authorities can properly take in the promotion of what is called the superpower development in the New England and middle Atlantic states. This conference is not conceived as more government in business. The public authorities are already deeply in the power business through many forms of regulation and a very large measure of control of power sources. The thought here is that coordination between public authorities and industries may secure further consummation of a great advance in the development of a great service to the public.

The reason and need for this discussion is simply that engineering science has brought us to the threshold

of a new era in the development of electric power. This era promises great reductions in power cost and wide expansion of its use. Fundamentally, this new stage in progress is due to the perfection of high voltage, longer transmission and more perfect mechanical development in generation of power. We can now undertake the cheaper sources of power from water sources further afield, such as the St. Lawrence and cheaper generation from coal through larger and more favorably placed generation plants. We can secure great economies in distribution through the interconnection of load between systems for thus we secure a reduction of the amount of reserve equipment, a better average load factor through pooling the effect of day and seasonal variations together with wider diversification of use by increased industrial consumption. We can assure more security in the power supply from the effect of coal strikes and from transportation interruptions.

All this means the liquidity of power over whole groups of states. At once power distribution spreads across state lines and into diverse legal juridictions. We are, therefore, confronted not only with problems of the coordination in the industries of their engineering, financial and ownership problems, but also with new legal problems in state rights and Federal relations to power distribution.

This super development of great areas of cheaper power has been dramatized by those less familiar with the problem, as the construction of great power highways traversing several states into which we should pour great streams at high voltages from great giant water power or central steam stations to be distributed to the public utilities and other large users along the lines of these great power streams. This, indeed, serves perhaps to picture what is meant by superpower development. As a matter of practical fact, however, the natural development of this situation lies first in the inter-

connection of power supplies between the existing great utility systems, and second, in common action for the erection of large units of production at advantageous points for the mutual supply of two or more of the present systems and in the development of such great water powers as the St. Lawrence.

Three years ago, at the instigation of our engineering societies the Federal government undertook an exhaustive study into the possibilities of more comprehensive and coordinated development in the northeastern states. This survey, under Mr. Murray's able direction, in which I also participated in an advisory capacity, demonstrated that the savings in these eleven states of a coordinated and fully developed electrical power system by the time it could be erected could amount to a conservation of about fifty million tons of coal per annum; that an annual saving could be made of over $500,000,000 per annum at an additional capital outlay of about $1,250,000,000. In this area we are today producing something like 9,000,000 H.P. by direct steam and individual plant generation, a substantial part of which could be transferred to central generation with great economy.

With the crowding of our population in large areas we are faced with most difficult questions in the development of terminal facilities, the handling of traffic on our railways. There has been some electrification of transportation. The engineers who have made systematic superpower surveys are convinced that over 40 per cent of the mileage of the railways in this territory could be electrified at substantial economies in operation and with enlarged service if we should secure this greater and more economical power development.

The indirect results both human and material are even more important than these figures I have given would imply. They do not take account of vast losses to industry and commerce by the actual interruption and

threatened interruption of fuel supplies to our several hundred thousand independent power units; no account of the relief to shippers from our already overburdened transportation and terminal facilities; no account of the increased production of our factories from cheaper power; no account of the larger extension of power into farm and home; in the reduction of physical labor, and increase of comfort.

To secure the rapid adoption of these demonstratedly possible results is of profound public importance. Every time we cheapen power and centralize its production we create new uses and we add security to production; we also increase the production; we eliminate waste; we decrease the burden of physical effort upon men. In sum, we increase the standards of living and comfort of all our people.

This new era of advanced projects is no theorists' or promoters' dream. It is a basic fact unanimously supported by our engineers; agreed to by the responsible men in the industry. It is true that there has been progress in the actual application of scientific advances in our national equipment, but we are far from the realization that is today practicable. I do not wish to be construed as stating that no progress has been made in enlarged coordination of power production and distribution. The electrical companies, under the regulation of the public service commissions, have already made excellent progress in the application of superpower principles in many localities. Power interconnections on the Pacific coast reach from the southern border of California to Oregon; the states of Illinois, Indiana, Wisconsin and Michigan are associated in a net work of interconnections as are Georgia, Alabama, North and South Carolina and Tennessee. This being the case—one purpose of this conference is to consider—why does this development in this, the greatest power zone of our coun-

try, where the greatest saving can be made, not make progress? What measures can be devised to stimulate it? What obstacles in its realization can be removed?

I do not wish to anticipate the results of the conference but I may point out that the state and national governments are blamed by some persons for this lack of progress. It is said that there is a lack of definite principles and of coordination in the policies of necessary regulation of power utilities by the different states and a lack of coordination and vision in our national administration of the development of nationally controlled power sources. It is also said that we should not permit the rivalry between our distribution systems and competition for territory to restrict the establishment of interconnection of load and the development of great generation units for their common use.

Whatever the fault may be it is the purpose of this conference to give preliminary consideration to the problems and principles that might be adopted in interstate relations; to discuss what measures can be devised to assure this needed development and what obstacles in its realization can be removed.

In the matter of public relations to power development and distribution it appears to me that one of the first principles we must realize is that the whole of this development implies the free flow of power. We have thus at once created at least a physical and economic interstate question. This great development of so much public interest cannot come about unless there is a complete liquidity in movement of power back and forth across the boundaries throughout the whole of the United States. We cannot secure centralized generation, great water power development, or interconnection of load unless there is this free flow. Without this we shall have permanently a larger cost of power and less expansion in its service. There are time-honored disputes over states rights with regard to water, and somewhat similar

questions are being raised as to power. Subject always to the sovereignty of states in taxation, etc., unless all citizens irrespective of state may have the same rights as to use of power we will destroy the hopes of a very economic development.

I am advised that it is probably true that no embargo could be constitutionally placed upon power flow across state frontiers but uncoordinated legislative and regulative actions by the states and national government might amount to economic embargoes and discriminations and thus stifle development.

Again my argument that we must have free interstate flow of power implies free flow within the states, and applies with the same strength to the complete necessity of state-wide regulation uninterfered with municipal obstruction. Otherwise we shall have the same dams erected and, thereby, an increase of costs and the destruction of the ultimate public advantages to be obtained in this necessity of life and growth.

The regulation of power distribution, profits or rates is a concept fully fixed into our governmental system.

The economical distribution of power rests, to a large degree, upon local territorial monopoly. Competitive overlap of power distribution systems would represent tremendous capital and distribution waste. When we accept the principle of monopoly we at once must accept the principle of public regulation. This is a fundamental conception upon which there is no need for dispute or argument. It is amply accepted by universal state legislation. Our states have wisely created public service commissions with state-wide regulatory power in order that rates, profits and distribution might be controlled.

I am not here to advocate Federal super regulation of interstate movement of power. I believe that power development and distribution would find its greatest solution in coordinated state regulation, perhaps with assistance and cooperation of the Federal government,

rather than in any super structure of authority such as has been found necessary in transportation unless, of course, necessities of the case cannot be attained otherwise.

In national relations to power development the public reaction against waste and exploitation of our national resources some years ago brought about a great movement for conservation, but it imported into the practice of conservation an implication of cold storage for these resources. We must adopt a new thought on conservation. Real conservation lies in use for public interest, not in prevention of use. Every water horse power that can be used today which runs to waste is a burden on man power, nor am I here to advocate that the Federal government abandon its policies in regard to conservation of national resources; but I do advocate their proper use for the nation, not the deprival of the public through old fetishes, old hates and inertia.

One phase of public relationship in this district is involved in the great water-power development of the St. Lawrence. It is of vital importance as an enormous contribution to the whole northeastern states. The American share would amount to 1,200,000 horse power producible at a cost far lower than any form of fuel generation. It is a pitiable waste today and can only be mobilized by cooperation of the Federal government.

In any event, the problems we are here to discuss are from a public point of view that by virtue of these scientific developments power has now become an interstate question. If, in our interstate conflicts, or national policies, we are hindering the development of progress of so fundamental a thing, it is but right that we should consider the subject in all of its aspects and seek to remedy it.

There is a phase of this whole public relationship that seems to me to be slowly emerging and that is that the

United States will naturally divide itself into several power areas. For instance, the barren area of power consumption formed by the Adirondacks on the east and the character of natural resources along the Mason Dixon line of the south create a natural district in the New England and mid Atlantic states. Another power district lies to the west of the Alleghanies and east of the Mississippi River. Still another district lies in the southeastern states, again in the southwestern states, and still another in the northwestern states. The problems in each of these power districts are essentially different as to the origins of power, the character of their industries, and are affected by the rate of probable industrial development in some states. And if we are to make rightful solution of national problems we should consider their development as essentially separate questions.

It is fitting that I should make some remark upon the remarkable progress and ability shown by the whole electrical industry since the days of Mr. Edison's initial genius. They have come to have a large vision of cooperation and service and have in very large measure realized their responsibilities to the public. One great mark of their progress is that despite the greatly increased cost of labor, coal and other materials, there is but little if any increase in the cost of light and power to the consumer today over pre-war prices. Under the protection of state regulatory bodies over two million of our people have invested their savings in this industry. From an annual utility production of 4,000,000,000 KW-hours twenty years ago we have increased to fifty billions today with an increase in consumption from 60 to 500 KW-hours per capita. It is a magnificient achievement of the initiative and ingenuity of these industries, and that it has attained such a growth under public regulation is itself proof of the ability and cooperation of our public officials, I believe that the same vision applied to

the wider problems which spread before us will maintain the same initiative and secure like progress in the future.

CONCLUSIONS OF THE SUPERPOWER SURVEY[1]

The market for superpower energy will be furnished by the electric utilities, the industries, and the railroads. The estimated requirement for energy supplied through the electric utilities for municipal, private, industrial, and railroad purposes in 1930 is 31,000,000,000 kilowatt-hours. This energy could be supplied by a coordinated power system such as is described in this report at an annual cost of $239,000,000 less than by an uncoordinated system such as is now in use. This amount represents the net saving after the necessary fixed charges on total capital expenditure have been deducted. The cost of uncoordinated power production in 1930 is computed from the cost of the present system in 1919. The total investment in generating and transmission facilities for the superpower system will be $1,109,564,000, of which $416,346,000 will represent the value of existing facilities to be incorporated into the system.

A study of the ninety-six thousand manufacturing establishments operating within the superpower zone shows that by 1930, through the maximum economical use of purchased electric energy, they can save $190,000,000 annually above the fixed annual charges against a capital investment of $185,000,000 to provide the motor equipment necessary to receive and use this power.

The combined capital investment necessary for the electric utilities and the industries as of 1930 therefore amounts to $1,294,564,000, and this total investment will yield annually above the fixed charges the sum of $429,000,000, or 33 per cent on the investment.

[1] By W. S. Murray. A Superpower System for the Region between Boston and Washington. [The Superpower Survey]. p. 12-15.

Within the superpower zone there are thirty-six thousand miles of railroad measured as single track—that is, including each track of main lines, yards, and sidings. Of this total about nineteen thousand miles can be profitably electrified, so as to yield by 1930 an annual saving of $81,000,000 as compared with the cost of operation by steam. The capital expenditure necessary to electrify the nineteen thousand miles would be $570,000,000, and the average return upon the investment would therefore be 14.2 per cent.

As defined in another section of the report, the superpower system begins at the generating stations connected to its lines and ends at the busses of existing electric utilities. Therefore, the cost of power discussed in this report means cost at the busses of the electric utilities and must not be confused with the cost to the ultimate consumer, which is necessarily much greater, owing to the added cost incident to secondary distribution systems.

Studies of the operations of each load center have shown that a large quantity of coal could have been saved had superpower facilities been available in 1919. On comparing the coal rates of power production in 1919 with those of the superpower system and applying the difference to the load that will exist in 1930 we find that the coal saved annually under the superpower system may be estimated as follows:

	Short tons.
Electric utilities	19,149,000
Heavy-traction railroads	10,210,000
Manufacturing industries	20,625,000
	49,984,000

The order in which the superpower steam-electric and hydroelectric power plants and transmission systems should be constructed must depend (1) on the present industrial demand for energy that cannot be satisfied because of the difficulties of the local electric utilities in financing extensions; and (2) on the future demand

for energy that will result from the more economical generation of power under the superpower system.

Many of the economies incident to superpower operation will be effected through the interconnection of existing plants and systems, and these economies should be increased as new power plants and interconnections are added. Certain steam plants that are under consideration and others that are under construction will be when completed as efficient as the proposed base-load steam-electric plants of the superpower system. Notable among these plants are the Hell Gate station now being constructed by the United Electric Light & Power Co. of New York city and the Delaware station of the Philadelphia Electric Co. However, by keeping in mind the two conditions, already stated, that should govern the order of construction, it is believed that the quickest return will be obtained by following in chronologic sequence the order of procedure outlined.

1. The construction of a steam-electric plant near Pittston, Pa., to supply a part of its energy to the anthracite division of the superpower zone and the remainder to the metropolitan division, particularly New Jersey.

2. The construction of a steam-electric plant near Sunbury, Pa., to supply a part of its energy to the anthracite division, a part of the Reading load center, and the remainder to Philadelphia.

3. The construction of hydroelectric plants on Delaware and Susquehanna rivers to supplement the steam plants indicated in paragraphs 1 and 2.

4. The progressive development of the Hudson River projects to meet the growth of energy requirement at the Schenectady, Utica, Poughkeepsie, and Pittsfield load centers.

5. The construction of a steam-electric plant near Boston to supply the Boston, Lowell, and Newburyport load centers.

6. The construction of a steam-electric plant near New Haven to supply the New Haven, Bridgeport, Waterbury, and Norwich load centers.

7. The partial construction of the first hydroelectric plant in the development of Potomac River as soon as the power demands of the Baltimore and Washington load centers require additional plant capacity.

Plant capacities are not stated above, as they cannot be finally determined except by further and more detailed study of local conditions combined with regional demands. The load growth at all the centers, however, will make it imperative to provide new plant capacity at an early date, so that construction of additional plants, as detailed in Appendix E, must be started promptly after the plants that will yield the greatest return have been built.

The territory in which the superpower survey has been made—the "superpower zone"—may be described as lying between the thirty-ninth and forty-fourth parallels of latitude and extending from the coast approximately one hundred and fifty miles inland, embracing parts of the states of Maine, New Hampshire, Vermont, New York, Pennsylvania, Delaware, and Maryland and all of the states of Massachusetts, Rhode Island, Connecticut and New Jersey. Within this zone is concentrated one-fourth of the population of the United States, and within it are operated, most of them independently, three hundred and fifteen electric utilities, eighteen railroads, and ninety-six thousand industrial plants. The superpower zone is the finishing shop of American industry.

Unlike the Pacific coast region, where water power abounds and industry is relatively small, the superpower zone has relatively small hydroelectric resources and maximum industrial-power requirements. When the increases during the last ten years are projected to 1930, even at a lower rate, the total energy requirement of the

zone in that year is found to be 31,000,000,000 kilowatt-hours, of which about 21 per cent can be supplied from water power.

Fortunately some of the best coal deposits in the country lie near this great industrial territory, and a prime economic purpose should be so to conjoin the hydroelectric supply of power to the steam-electric supply as to produce a maximum of energy for a minimum investment of capital and a minimum operation expense and at the same time to conserve the rapidly disappearing cheap fuels of the Appalachian coal fields.

The superpower system here recommended comprehends a plan of power production that includes the generation of electricity by steam at tidewater and on inland waters where a sufficient quantity of condensing water can be obtained, and also the utilization of all hydroelectric power that may be economically obtainable from rivers within the zone or within transmission distance of it. The electric power so generated will be coordinated through a system of interconnected transmission lines, the potentials of which will be on the order of 220,000 and 110,000 volts. (For the assignment of these voltages see Appendix E.)

Plates II and III show how the superpower system should appear in 1925 and 1930. They give the locations of the new steam-electric plants, the hydroelectric plants, and the load centers for each year and show the interconnecting network of transmission systems required. Had superpower been available in 1919 the number of load centers to which its power could have been supplied economically would have been twenty, and this number as the maps show, will increase to thirty-four in 1930.

Under the present independent operation of the electric utilities and the manufacturing industries in the superpower zone the existing power plants are numerous and small. The average capacity of the five hundred fifty-eight electric-utility plants now in operation in the

zone is 7,900 kilowatts, and that of the steam-electric plants 10,000 kilowatts, while the hydroelectric plants average only 2,800 kilowatts. Out of ninety-six thousand industrial establishments in the superpower zone seventy-six thousand use power, and each of these isolated plants averages about 350 horsepower. Under the superpower system, by contrast, the number of power stations required to supply the entire zone in 1930 will be only two hundred seventy-three, of which two hundred and eighteen will belong to the existing electric utilities. The capacity of the base-load steam plants will range from 60,000 to 300,000 kilowatts. In none of these plants will there be installed a turbo generator having a capacity of less than 30,000 kilowatts.

The new power stations and load centers will be so located with reference to the existing electric-utility plants that are to be incorporated in the system as to insure the maximum aggregate economy in power generation and transmission. A prime object to be attained in the superpower plan is the maximum economic utilization of existing generation and transmission equipment. In the early stages, while the superpower system is taking form, existing electric-utility capacity will predominate. Indeed, in 1930, as much as 31 per cent of the total superpower capacity will be contained in plants belonging to the present electric-utility companies.

The superpower system would and should fail to achieve its purpose if it should seek to supplant or even to compete with the existing electric utilities. Its object is exactly the reverse. In view of the great economies already effected by the electric public utilities, the creation of the superpower system can be urged only as it shall come into being to coordinate and supplement these utilities and carry to a higher degree the service and the economies incident to their present operation.

It should not be difficult to see, therefore, that the superpower system will provide for a series of load

centers, at which power may be made available at lower cost than can be attained under the present unassociated systems of power production and distribution. At these load centers, located where economy may dictate, power so made available will be coordinated with power generating at existing electric-utility plants and distributed by transmission or distribution systems to the consumers, as it is today.

Under the heading "Summary of conclusions" it was stated that in the operation of electric utilities the superpower system, in comparison with independent operation, would save $239,000,000 in 1930. The question might be asked, could not the same result be attained by the electric utilities themselves in the course of their normal expansion? The coordinated plan of power production by the superpower system represents the highest possible commercial efficiency and must therefore yield the maximum economies. I believe that no possible expansion of the present uncoordinated electric public utilities can reach the economic results promised by the superpower system for the physical structure of the superpower system as outlined in the appendixes to the report, employs minimum capital and minimum labor to produce a maximum of electric energy.

In the discussion of the superpower system there has been some tendency to look upon it more as a company than as a principle, but the foregoing statements should make it clear that superpower is merely a name for the principles that should govern the expansion of the existing electric utilities. A better term than superpower would have been superutility.

The electric utilities, the railroads, and the industries within the superpower zone have freely given their data to permit a determination of the amount and location of load and demand and have supplemented them with data showing the cost of producing their power in 1919. The superpower system will be a regional system supplying

power through the electric utilities, at the highest economy, to the two agencies that are most vital to American existence—industry and transportation. The highest economy in investment and operation will be gained by maintaining the size of the electric generating units at a maximum and thus reducing capital and operating cost to a minimum. The highest economy resulting from diversity economy will be gained through a wisely ordered interconnecting system of lines of transmission and distribution—a system which also offers the highest economy in the development of water power, for it makes possible the use of a maximum number of cubic feet of water per square mile of drainage area, thus reducing to a minimum the amount of power generated by steam.

In determining the amount and cost of the power produced within the superpower zone it was obviously necessary to select the latest year for which full construction and operating information could be obtained—the year 1919. On account of the extremely high cost of material in that year, however, this selection has introduced high fixed charges; but this is offset by the saving in high-priced coal and the consequent reduction in operating expenses resulting from the higher efficiency of the superpower system as compared with the present independently operated electric utilities.

As efficiencies have increased with the enlargement of the plants operated, the cost of producing power has been lowered. The best reflection of this decrease in cost is seen in the electric utilities themselves. Much of it has been the result of interconnection, which has permitted the use of larger machinery and a better utilization of water power. In the isolated plants and on the railroads, however, although the cost of power has been lowered, the decrease has been far less, because in both of these the power equipment is small and its operation is affected by conditions that prevent much gain in efficiency.

It may be argued that it would be unfair to extend the costs of independent operation for 1919 to 1930 and at that year strike a difference between them and those of the superpower system. This argument cannot be gainsaid, but if the figures representing the cost in 1919 of unassociated power production are not lowered by 1930 then the full savings previously indicated as possible by the superpower system can be claimed. Unquestionably the figures for 1919 will be lowered by the further consolidation of existing utilities, but unless the electric utilities act in complete cooperation and themselves adopt a plan of coordinated expansion by which the load centers of the zone can be supplied with power at minimum cost then the economies they can independently effect will never reach the maximum attainable under the superpower system, which involves the complete coordination of the existing power stations of the electric utilities and the new stations to be constructed.

ONTARIO'S EXPERIENCE[1]

That more than three hundred and eighty municipalities acting cooperatively have invested about $250,000,000 in a common undertaking for the distribution of electrical energy to their citizens, that this organization has been in successful operation in Ontario for nearly fifteen years and that it is accumulating large financial reserves while supplying electric light and power over extensive areas at unprecedentedly low rates, are facts which have attracted world-wide attention.

In its essence, the "hydro" electric power undertaking of Ontario is an organization of a large number of partner municipalities, coordinated for securing common action through the medium of the Hydro-Electric Power Commission which acts as their trustee. As such, the commission generates or purchases electrical energy

[1] By Sir Adam Beck, chairman Hydro-Electric Power Commission of Ontario. Survey. 51: 585-90, 650. March 1, 1924.

which it transmits to the associated municipalities. Each year it allocates the entire cost of operation of each system among the respective partner municipalities, so that these contribute each its own proper and proportionate share toward the cost of operation. Each municipality owns its local distribution system and distributes the power to its individual customers. These individual customers, in turn, are charged rates which will meet the cost of power furnished to the municipality by the commission, together with the cost of operation and management of the municipal distribution system.

Absence of coal resources in the province, advances in the art of transmitting electricity, and recognition of the manufacturing potentialities of the country, were the three chief factors which, about 1900, prompted a number of leading manufacturers in southwestern Ontario to look into the possibility of obtaining hydro-electrical energy at rates cheaper than the cost at which power could be generated locally from coal, gas or oil.

It was realized that if the large water-power of the Niagara River could be used as a basis for the widespread transmission of electrical energy throughout the more populous portions of Ontario, then importations of coal could be substantially reduced and Ontario would, thereby, be rendered less dependent upon foreign resources. Interest in Ontario's power problem was greatly stimulated by public meetings, and discussions in the press. Appeals were made to the provincial government for legislation, and finally, as a result of the general movement, the government of Ontario, in 1903, provided the means by which a commission could be appointed by interested municipalities to investigate the generation and distribution of hydro-electrical energy. The authority thus granted resulted in the appointment by the municipalities of Toronto, London, Brantford, Stratford, Woodstock, Ingersoll and Guelph, of the Ontario Power Commission, which after a thorough investigation, published a comprehensive report in 1906. When the results

of this investigation became known, the provincial government, that same year, provided by special act for the creation of the Hydro-Electric Power Commission of Ontario, the organization now in existence. With the exception of the chairman, the personnel of the commission has changed from time to time, but it is noteworthy that the services of many of the commission's most important officers commenced with its creation and—notwithstanding several changes in the governments of the Province—they are today in responsible charge.

In 1906, by-laws were passed by thirteen Ontario municipalities authorizing their councils to make contracts with the commission for a supply of electrical power from Niagara Falls. In 1907, further legislation strengthened and extended the powers of the commission. One essential difference between the act of 1903 and those of 1906 and 1907 is, that under the former various municipalities could combine into separate groups operating through separate commissions, whereas under the later acts all municipalities make their wants known to the provincial commission which is then able to harmonize their various requirements and coordinate the municipalities into groups or districts.

Those entrusted with the formulation of the policy to be pursued by the commission were impressed with the underlying strength of the industrial and commercial possibilities of the territory seeking the cheaper power and light. Southern Ontario, the area served by electrical energy from Niagara, lies approximately between latitudes 42 and 44. The greater part of this area is further south than much of northern New York state, than the larger portions of the states of New Hampshire, Vermont, Michigan, Wisconsin, Minnesota, South Dakota, Idaho and Oregon and than the whole of the states of Maine, North Dakota, Montana and Washington. Compared with Europe the area lies in the same latitude as the south of France. The Province has many

climatic advantages. That precipitation throughout Ontario, both in amount and in its seasonal distribution, is sufficient for agricultural purposes and is an asset of prime importance. The whole Province is well watered and with its many streams and lakes replenished from the annual precipitation, the water power developments are in most instances exceptionally well protected. Its agricultural advantages for mixed farming and fruit-growing are well known. Its railway and inland facilities are excellent. In all the large municipalities, the employer of labor contemplating the establishment of new industries may count upon adequate transportation facilities, unsurpassed educational and social conditions, and standards of living and of administration of public affairs equal (in many cases superior) to those to be found elsewhere.

From this brief consideration of the natural advantages of the Province it will be appreciated that with Ontario's background of agriculture, its timbering, mining, fisheries and game, there are available supplies of raw materials for an extensive manufacturing industry with marked possibilities for increasing exports from farm and factory. Such circumstances, then, constituted a solid foundation of great promise upon which the commission could build in establishing a market for the consumption of electrical energy for domestic, commercial and manufacturing requirements.

The lines along which the commission has conducted its work are easily grasped.

If the people of a municipality want to obtain a supply of power, a vote is taken at the polls, and an enabling by-law passed whereby the municipality may contract for it with the commission. The commission's engineers are at the service of the municipality for the purpose of making an estimate of its requirements. The contract having been executed, a money by-law must also be passed by the electors authorizing the municipal council to issue the debentures necessary to cover the cost of

constructing a distributing system within its limits. The commission thereupon proceeds with the work of building up the necessary transmission lines, sub-stations, etc. The municipalities repay the cost of the project out of earnings, spread over a period of thirty years; all such items as maintenance, depreciation and sinking fund being fully taken care of. At the end of thirty years' time the entire plant and equipment will have been paid for, and the people become the owners of a fully-paid-up undertaking.

The basic principle of the whole "hydro" project is a parnership of municipalities formed to obtain electrical energy at cost, each municipality paying its proportion of the cost for the service received. The commission, acting as trustee and agent for the municipalities, exercises both administrative and constructive functions, and has evolved a well-defined and successful working policy for the development, transmission and distribution of hydro-electrical power under municipal ownership.

The fundamental basis on which power is supplied is that it must be sold "at cost," but not every one is aware just what is meant by this term. "Cost," so far as "hydro" power is concerned, includes all charges arising out of the generation, transmission and delivery of power to the municipalities. These charges include, for each municipality, its share of the interest and sinking fund for the cost of lands, stations and equipment required for supplying power as well as a proportionate part of administration, operation, maintenance, renewal, insurance, and all other costs entering into the business of supplying electricity.

The framework of the financial structure of the hydro-electric systems may be set in a few concise statements:

First: The generation and transmission of power on a wholesale scale is dealt with by a commission which, although appointed by the government of the Province,

acts independently in the capacity of trustee and agent for the partnership of municipalities.

Second: The local distribution of electrical energy within the borders of a municipality is, in general, under the administration of a public utilities commission appointed under the provisions of the Public Utilities Act.

Third: Capital required for the plant for the generation and transmission of power is provided by the government upon receipt of formal requisition from the commission. Contracts are entered into between the commission and the municipalities under the terms of which the municipalities undertake to repay in thirty years the monies thus loaned by the government.

Fourth: The local distribution system is financed by the issue of municipal debentures. Provision is made in the rates charged to the ultimate consumers, for revenue with which to retire these bonds also, usually in twenty years.

Fifth: The "trustee" commission supplies power to the municipalities, charging each municipality the actual cost. To do this, an interim charge is made monthly based upon the estimated cost, and, at the end of each year, credit or debit adjustment is made of the amount charged, in order to make up the actual total cost—no more and no less. The "cost of power" includes all the usual costs of operation and maintenance of the generating, transforming and transmission plant and equipment, and, in addition, the annual interest charges on the monies borrowed for the initial cost of installation, also provision for renewal (depreciation) and sinking fund reserves, as well as a special reserve fund for contingencies.

Sixth: Each municipality sells electrical energy to its local consumers at rates and under conditions approved by the commission. The rates charged to its consumers by a municipality are sufficient to take care both of the cost of distribution within the municipality and of the

estimated cost of power to be paid to the commission by the municipality. The cost of distribution is ascertained in a manner identical with that used by the commission in arriving at its wholesale costs.

Seventh: Under the Power Commission Act, the commission is required to determine, annually, the actual cost of service supplied to the municipal corporations by the local commissions for such strictly municipal purposes as street lighting and operating electric-motor-driven pumps in waterworks, and if any profit has accrued through the charging of the rate used throughout the year, this surplus is handed back to the municipal system.

At the outset of the commission's work, after studying various sources of power for distribution to the municipalities it was concluded best to initiate their co-operative enterprise by purchase from power companies which had extensive plants already erected at Niagara Falls. Consequently in 1908 the commission, on behalf of the municipalities, entered into a contract with the Ontario Power Company for the supply of 100,000 horsepower of electrical energy at $9.40 per horsepower-year until a load of 25,000 horsepower should be reached, after which the price was to be $9.00 per horsepower-year. The commission built transformer stations and transmission lines for distributing the power to the contracting municipalities, and by about the end of 1910 was supplying ten urban municipalities. The small initial load of less than 1,000 horsepower increased until in 1914 it was 77,000 horsepower, and by 1915 the commission had reached the limit of its contract for 100,000 horsepower. In 1920 the load was 356,000 horsepower. The commission had arranged meanwhile for additional power supply from the Canadian Niagara Power Company of 50,000 horsepower, and from the Toronto Power Company of over 25,000 horsepower. It subsequently purchased outright the Ontario Power Company with its plant capacity of 160,000 horsepower, and more recently

THE HEAVY BLACK LINES SHOW THE POWER TRANSMISSION SYSTEM WITH ITS SOURCE AT NIAGARA FALLS. MUNICIPALLY OWNED AND OPERATED UNDER THE HYDRO-ELECTRIC POWER COMMISSION OF ONTARIO, CANADA

acquire the Toronto Power Company with that of 125,000 horsepower. Finally, in its new Queenston-Chippawa plant the commission has provided for an ultimate development of 600,000 horsepower.

The extent of the commission's operations is registered by the fact that the high-tension lines alone in its transmission networks aggregate over three thousand miles.

The municipalities now own and operate a number of hydro-electric systems, including power plants. These systems are: Niagara, Severn, Eugenia, Wasdells, Muskoka, St. Lawrence, Ottawa, Rideau, Thunder Bay, Central Ontario and Trent, and Nipissing. Of the foregoing, the Central Ontario and Nipissing systems were purchased by the provincial government in 1916, their operation being entrusted to the commission.

Since commencing its operations, the commission has purchased no less than twenty waterpowers, thirty hydraulic generating plants, and over sixty electric distribution systems. It possesses the right to expropriate private plants; nevertheless—with the single exception of a case at present under consideration—the commission has not required to invoke its powers of expropriation, but has been able to consumate every transaction upon fair terms, satisfactory to the interests immediately involved.

Today, including exported power, the Hydro-Electric Power Commission of Ontario is distributing about 700,000 horsepower, and operates twenty-one undertakings which, when fully developed, will have a potentiality of over 1,000,000 horsepower.

The province of Ontario is the owner of Canada's equity in the water power in the international portion of the St. Lawrence River; this share amounts to over 800,000 horsepower. It often takes several years to prepare the plans and construct the installations necessary to supply large quantities of power, and those who have

followed the phenomenal growth in demand for electrical energy will appreciate that it is one of the functions of an organization like the Hydro-Electric Power Commission to appraise existing conditions in the light of future needs. Present conditions clearly indicate that the power markets will be short of power before the St. Lawrence River hydro-electric power can be made available even though the work were commenced immediately.

The greatest individual engineering project which the commission has undertaken is the Queenston-Chippawa power development of the Niagara River. Its general scheme comprises an intake structure in the Niagara River at Chippawa; the deepening and widening of the Welland River between Chippawa and Montrose, a distance of four and one-half miles; the construction of a canal eight and one-half miles long from Montrose to the forebay and screen house at a point on the cliff about a mile south of the village of Queenston; and the construction and equipment of a power house, in the gorge, immediately below the forebay.

Existing power developments on the Niagara River have only utilized that portion of the total fall of the river which occurs in the vicinity of the falls and, for the most part, even this amount of head has been ineffectively utilized. The basic conception of the Queenston-Chippawa development is the utilization of the greatest possible amount of the total fall of the Niagara River between Lake Erie and Lake Ontario at the highest possible efficiency. Of this total fall of three hundred and twenty-seven feet, about 10 feet occurs in the upper Niagara River from Lake Erie to Chippawa and in the lower river from Queenston to Lake Ontario. These ten feet it is impossible to reclaim for power purposes. Of the remaining head, about twelve feet is required to convey the water through the canal.

The average head actually available at the power house is three hundred and five feet, and 30 horsepower

is developed for every cubic foot of water that flows through the canal per second. That this is a great forward step in economy is apparent from the fact that only 16 horsepower is obtained from each cubic foot of water flowing per second in the most efficient of the present three plants on the Canadian side of the river at Niagara Falls, thus every cubic foot of water used in the Queenston power house will earn nearly twice as much revenue as if it were used at the falls.

The water of the Niagara River, after leaving the canal proper, enters a forebay which is practically a triangle-shaped enlargement of the canal, whence it enters the penstocks, or tubes, which lead it down the face of the cliff to the turbines in the power house which is located right on the edge of the river at the botom of the gorge.

The turbines are technically described as of the vertical single-runner type; their capacity is 60,000 horsepower each, being greater than that of any others previously built.

Each electric generator is mounted directly above its own turbine, the revolving parts of each having a common shaft. The heaviest single integral part of one of these huge units weighs three hundred tons. Air is employed for cooling these generators and the warm air issuing therefrom is used in winter to warm the building; the weight of air required every two and one-half hours for cooling each generator is six hundred and ninety tons, equalling the total weight of the generator itself.

Three-phase alternating electric current is generated at 12,000 volts, the frequency being 25 cycles per second; the current from each generator passes through its own switches and transformers the latter being used to step up the voltage from 12,000 volts to 110,000 volts; and the current is transmitted at 110,000 volts on the commission's high-tension lines all over southwestern Ontario.

Six of the large new generators are now supplying the Niagara system, while of the remaining generators, two are under order for earliest possible delivery. The power canal provides for an ultimate plant capacity of over 600,000 horsepower.

The following table, based upon returns published in the last annual report of the municipalities, will convey some idea of what the charges are for light and power in some of the larger municipalities of Ontario:

Charges for Light and Power Service in Ontario Municipalities

Municipality	Population	Approx. Transmission Distance in Miles	Average Net Charge to Consumers Inclusive of All Charges		
			Residence Cents per Kilowatt-hour	Commercial Cents per Kilowatt-hour	Power Dollars per Horse-power per Year
Toronto	512,812	90	2.2	2.8	$21.00
Hamilton	114,766	50	2.1	1.2	13.63
Ottawa	110,708	1	1.6	1.8	13.52
London	59,281	132	1.9	1.7	25.14
Windsor	37,170	248	3.0	3.1	23.78
Brantford	32,786	85	1.8	1.4	19.56
Kitchener	23,027	102	2.4	1.8	16.60
Peterboro	21,790	2	2.9	1.8	15.97
St. Catherines	19,862	9	1.4	1.5	14.56
Guelph	17,922	77	2.7	2.4	14.41
Galt	13,092	93	1.8	2.0	14.45
Niagara Falls	14,805	1	1.6	1.5	13.26

The success attained by the Power Commission in distributing hydro-electrical energy, not only to the larger cities and towns but to villages and hamlets, stimulated the farming communities of rural Ontario to call for "hydro" service. The problem of distributing power economically to farms is a very difficult one. The individual demands for power are quite small and irregular; also the distances to be traversed are relatively great. In 1921, a provincial act—the Rural Hydro-Electric Distri-

bution Act—was passed which recognized both these handicaps and also the desirability, in the general interest, of bringing the benefits of electricity to the farm. It provided a bonus on rural primary lines to the extent of 50 per cent of their cost. This policy has been generally approved; during 1922, approximately four hundred and forty miles of rural distribution lines were constructed to give service to over twenty-six hundred consumers, and at present, the rural lines approved by the commission aggregate over one thousand miles and give service to about fourteen thousand consumers.

Although the aggregate load of the electrical energy thus distributed to rural dwellers is relatively quite small, its influence on the economic life of the Province is already a factor of great importance. The problem of keeping the younger generation on the farm and making farm life attractive is greatly helped and in some cases solved by the coming of electrical service.

Although the province of Ontario has many water powers, distributed throughout its area, nevertheless, the extensive natural storage of the Great Lakes, resulting in the exceptionally uniform flow of the Niagara and St. Lawrence rivers, coupled with their concentrated falls and rapids, and the satisfactory basic engineering conditions for development, make these rivers unique for the furnishing of large quantities of hydro-electricity at low cost.

It should be recognized that along with the development and widespread distribution of electrical energy under cooperative municipal ownership, there has also taken place in various parts of the Province a great development of electrical energy for individual industrial purposes. The favorable provincial legislation, the low rental imposed upon bona fide developers of power, as well as many other factors contribute to facilitate the satisfactory utilization of provincial water powers for the development of new industries.

Power has been extensively used for the development of the pulp and paper industries; similarly, it has contributed to the success of mining operations such as are conducted in the Cobalt, Porcupine, Sudbury, and other districts of northern Ontario. Nickel, silver, gold, iron and other metals as well as many non-metallic minerals are known to exist over extensive areas in Ontario, and water power in the future will no doubt be requisitioned to an increasing extent in this connection.

Those who initiated the plan for the work of the Hydro-Electric Power Commission of Ontario were most particular to protect the operations of the commission from so-called "politics." That is to say, there was to be no political domination in the appointment of employees, in the purchase of supplies and equipment, or in other matters. It was recognized that such domination or interference inevitably tends toward inefficiency and mismanagement.

The success of the hydro undertaking would have been impossible without the mutual respect and confidence which have existed among the various municipalities themselves, and between these municipalities and their commission. On the part of all concerned there has always been recognition of the solidarity of the interests involved and it is known that just so long as the necessary respect and confidence are maintained and political influences are eliminated, it will be impossible for any attacks to result in depriving the people of Ontario of the great advantages which they now enjoy as a result of their cooperative effort.

There has been a great deal of unfair opposition to the program of the municipalities in their hydro-electric undertaking, but criticism of the results obtained has come almost entirely from outside sources. Probably no public reform has experienced more misrepresentation than has the work of the commission.

The many unjust attacks directed against the commis-

sion have usually followed along a well-beaten track. They have consisted of grossly incorrect and misleading statements; the garbling of documentary and other data relating to the commission's work and employing such garbled material as premises from which to derive conclusions. Pronouncements have been made based upon comparisons so inadequate as to be puerile; pertinent engineering data has been disregarded; comparisons have been made between unlike quantities and involving unlike conditions so that the comparisons drawn have been useless; considerations of engineering economics have been ignored; and erroneous statements have been made in a most dogmatic manner in the hope of imposing upon the credulity of those not having knowledge of the facts.

By such unjust processes, the work of the commission has been grossly misrepresented, but in spite of it all the work has prospered beyond all expectation.

No matter where from or how the attacks have originated, they have never come from the over three hundred and fifty municipalities whose citizens know that their own "hydro" enterprise is a great success—a success of which they are specially reminded every month as they pay their relatively small monthly bills for electrical power and light "at cost."

THE ARGUMENT FOR SUPERPOWER [1]

Because our people must have abundant and cheaper power, cheaper transportation, better and cheaper living, and because these advantages should be made available to all of them without the exclusion of or discrimination against any class—for these reasons and many more, Pennsylvania has taken the lead in the matter of what we have named "giant power."

[1] By Gifford Pinchot, Governor of Pennsylvania. New York Times, August 3, 1924.

Giant power is not a mere phrase to catch the eye and give a new meaning to an old and limited idea; it was coined to visualize the vast economic and social project which Pennsylvania has set on foot, and for the preliminary survey of which she has appropriated $35,000.

The Giant Power Survey Board, which is making this preliminary survey, will report to the General Assembly of Pennsylvania next January an outline plan of the policy which should be followed and the measures which should be adopted as our part of the effort to realize what I believe will bring about the rescue of the railroads and farms for their present economic and social difficulties, the strengthening of our manufactures, and the enrichment of the life of the people generally.

"Giant power" is a further development of and a radical advance from the proposals put forth under the name "superpower" some years ago. Giant power is elementally simple in conception, notwithstanding the fact that it must be tremendously complicated in materialization.

Big Saving Expected

The ends we have in view which were not specifically included in the superpower idea are the providing of current to the rural population, trunk line railroad electrification, giving the benefit of this saving to all the people of the state, leading to radical reduction in rates, especially to the smaller consumer, and at least in proportion to the reduction in costs.

The way we propose to attain these ends is through:

1. The generation of electricity in steam stations of very large size, say of 650,000 horsepower capacity, so as to secure all the economies possible from quantity production.

2. The location of these stations at or near the coal mines, so as to eliminate wasteful railroad haul.

3. The recovery in these stations of the by-products of coal, often more valuable than the coal itself, so as to reduce the actual cost of fuel to a point that should put electric current at these stations on an equality as to cost with current from the best water power sites, such as Niagara.

4. A trunk system of transmission lines reaching 220,000 volts capacity, so as to reduce the cost of transmission.

5. The assembling or integration of power, transmission and distribution systems into one physical service unit regardless of ownership, so that the economies of generation and transmission may be passed on to the public throughout the state.

Through such state-wide physical integration, and in no other way, can the very limited water-power resources of Pennsylvania be fully utilized and their benefits distributed throughout the commonwealth. For this, great storage reservoirs are necessary, such as have been in part constructed on the Clarion River and have been authorized on the Wallenpaupack.

These projects are the most intensive large-scale development of water power within my knowledge, in that they aim to store the whole flood of each of these streams and use it for carrying the daily peak load of the steam electric systems with which they are linked.

The specific ends we have in view may also be very simply stated:

1. The general extension of electric service to every farm throughout the commonwealth.

2. The electrification of trunk line railroads.

3. Radical reductions in rates to be made possible through the economies of integration already described.

The extension of electric service to the farms will itself be an economic revolution. The farmer has been the victim of the age of steam. His productive power, though increased by the invention of ingenious horse-driven machinery, has remained relatively stationary, as

compared with that of the manufacturing workman. The comforts, conveniences and freedom won by the townsman in the nineteenth century were denied to the farmer and his family.

These handicaps have been to some extent lessened by the automobile and the gasoline engine, which have made fuel power in small units available for the first time for the farmer's needs. But electric power, because of its flexibility, ease of control, and absence of need for special mechanical skill in the use of it, is as much superior to the gasoline engine as that engine is to animal power and the power of human muscles. It alone can put the farmer on an equality with the townsman and afford a basis for a permanent and wholesome country life.

Electrified Railroads

The electrification of the trunk-line railroads of Pennsylvania would be an enormous service to the whole country. About 30 per cent of the freight cars of the United States are used to carry the output of coal mines, either in the form of coal or of coke. and about 25 per cent of this mine output, or 7½ per cent of the railroad loadings, is consumed by the railroads themselves. If power is transmitted over wires from the mines instead of being hauled in coal cars, a vast number of cars and locomotives will be set free to haul higher-grade and better-paying freight. This alone might well solve the financial problems of the railroads and bring about reduction of freight rates.

Perhaps still more important is the higher efficiency of the electric locomotive and its flexibility as a traction agent. The steam locomotive, measured by results for each pound of coal consumed, is the most wasteful of all power generators, even under good weather conditions, to say nothing of great heat losses during the winter months. The electric locomotive is peculiarly adapted to mountain grades, since it can, on the down grade, feed back upon the wire a large fraction of power consumed

by it on the up grade, thus saving the gravity energy that the steam-drawn train wastes in the friction of braking and in wear and tear on equipment.

How Rates Will Be Lowered

Our expectation of a radical reduction in rates is based upon the belief that the economies of low-cost generation in giant power steam stations near the coal mines, and of low-cost transmission over trunk lines of very high voltage, can be passed on to the consumer by a thorough-going integration of electric service systems.

No such linking up of separately owned systems now exists in Pennsylvania or elsewhere in the United States. What does exist in certain places, and even that is a recent development, is in most cases interconnection between two or more systems at points relatively few and unimportant.

This interconnection usually takes place at the extremities of two webs of transmission lines, each owned by a separate company. The voltage of each web normally decreases from the power house to the extremity of the web, and the interconnection is therefore at relatively low voltage. I have compared such interconnection to the interlacing of the branches of trees growing on opposite sides of a street; though the extreme twigs touch, only a squirrel can cross on them.

What is needed is something like a great bridge over the street or a big subway under it by which the heaviest traffic can cross. Integration of this kind is a conception justified by the wonderful advances in the art of long-distance electric transmission and shared by the great leaders of the industry.

When this conception is generally applied, we shall have great power districts whose limits are fixed only by the practicable transmission distance. This will embrace the entire industrial region of the northeastern section of the United States, from Maine to Maryland and from the coast to central Ohio; anything less than that means

waste, which again means high prices and inadequate service. Through the Giant Power Survey Commission Pennsylvania is putting her house in order to take her proper place in such a system.

A Public Task

It goes without saying that such an integrated system, in so far as it is privately owned, must be under public control, working smoothly, promptly and cheaply. Ways must be found to apply to it and its component parts the principles of the Federal Water Power Act; and there must be a fair apportionment of the benefits among different classes of users according to standards fixed by general considerations of public welfare, rather than by some manager's vision of quick and easy profits.

In short, the privately owned electrical industry and the regulating bodies of the several governments served by it must make good the claim so generally put forth, often in good faith, that private enterprises can supply power more cheaply than public enterprises. This claim must be put to the test of actual experience in a fair field, with no favor on either side.

The General Assembly of 1923 created the Giant Power Survey Commission to point the way to these objectives. The commission has appointed Morris L. Cooke, an engineer of distinction, who was formerly Director of Public Works in Philadelphia, to carry out the work of the survey with a corps of expert assistants. The commission is to report next January a policy for adoption by the commonwealth to insure the benefits sought by the survey.

This report should be the foundation stone upon which Pennsylvania will build her portion of the giant power system for the northeastern section of the United States. We hope for and confidently expect the cooperation of the other states in this region in this endeavor to secure for the people of all of them more power and cheaper power, and, therefore, better living at less cost.

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